Agricultural Commercialization, Production Diversity and Consumption Diversity Among Smallholders in Ethiopia:

Results from the National Ethiopia Integrated Survey on Agriculture, Rural Socioeconomic Survey, 2012

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Introduction:

The international nutrition community has renewed its commitment to multi-sectoral, 'nutrition sensitive' approaches to improved nutrition, through pathways that stimulate the income and production capabilities of smallholders. Among the many interventions being rediscovered by nutrition practitioners, two in particular -- attention to improving production diversity, and smallholder commercialization -- are viewed as potentially promising mechanisms for stimulating the quantity and quality of dietary intake by smallholder households and for improving nutritional status. Evidence of the relationships between increased production of nutritious food crops, the diversity of crop production, and linkages to improved overall dietary quality is inconclusive. Similarly, there remains controversy over whether commercialization leads to improved dietary intake and nutrition status and for whom.

The study sought to answer the following questions: 1) Is agricultural commercialization associated with greater household dietary diversity and, if yes, under what circumstances? 2) Is greater food production diversity associated with dietary diversity? To what extent does the production of a specific food group increase the likelihood of its consumption? 3) What other factors are associated with dietary diversity among smallholder rural Ethiopian households, and how do these factors interact with commercialization to affect dietary diversity outcomes?

Methods:

The study uses a unique, recently released national level data set from Ethiopia: the "2012 Living Standards Measurement Study-Integrated Survey on Agriculture, Ethiopia Rural Socioeconomic Survey" (LSMS-ISA: ERSS), implemented by the Ethiopian Central Statistics Agency (CSA) with technical support from the World Bank. The purpose of the LSMS-ISA:ERSS was to integrate data collected in the Ethiopian annual Agriculture Sample Survey with socio-economic, nutrition, and other multi-sectoral data typically collected through LSMS-style surveys. The analysis was limited to 2,234 smallholder households who met the criteria of involvement in crop production and cultivating a field area of less than 2 hectares. Household dietary diversity was measured using the Household Dietary Diversity Score (HDDS). Agricultural commercialization was defined as the total annual income earned from the sale of crops, livestock, and all agricultural byproducts. Data limitations did not allow us to also examine the ratio of the value of crops produced vs. sold. Two indices of the number of food crops produced and cash crops produced were constructed to examine production diversity, with cash crops defined as chat, coffee, cotton, enset, hops ("gesho"), sugar cane, tea, tobacco, and sisal. In addition to descriptive analyses, Ordinary Least Squares (OLS) regression was conducted to test the associations between agricultural commercialization and dietary diversity, production diversity and dietary diversity, and other predictors of dietary diversity while controlling for non-agricultural income and other possible confounders. Additionally, logistic regressions were used to predict the odds of the consumption of specific food groups, including dummy variables for whether the food group was produced and metrics of agricultural income quartile, non-agricultural income, and whether any amount was sold.

Findings:

Results of this study suggest that smallholder commercialization in Ethiopia has a significant and positive relationship to household-level dietary quality. Greater income from agricultural sales, controlling for non-agricultural income and other confounding variables, was associated with higher household dietary diversity, with female-headed households experiencing greater positive effects from commercialization than male-headed households. Furthermore, greater agricultural income significantly increased the odds of both vegetable and dairy consumption. Other variables found to be strong predictors of household dietary diversity were: share of agricultural income from livestock sales, field area, distance to a major market, region, chat expenditures, education, wealth, and female ownership of a large asset (a proxy for empowerment).

Regression analysis showed no effect of food crop production *diversity* on consumption diversity, controlling for other confounders. That said, cash crop production (a binary variable) was found to be a significantly positive predictor of dietary diversity. Regardless of cash crop production and across all income levels, households that produced vegetables, fruit, pulses, dairy, and eggs had a higher chance of consuming these foods than those that did not produce the foods at all. Selling these crops was not found to significantly affect their consumption.

Certain limitations of the data must be kept in mind in interpreting these results. First, the data were cross-sectional, leading to potential endogeneity in the analysis. Second, due to the lack of yield data we were unable to account for the quantity of crops produced (only the variety). Yield data would also have enabled us to define commercialization as the proportion of total harvest sold, a useful complement to the 'total agricultural income' indicator used in this analysis. Many of these limitations will be addressed through the collection of primary data as part of the USAID/Ethiopia ENGINE-funded Agriculture-Nutrition Panel Survey, a longitudinal survey of 1200 rural households that will be implemented four times, across two seasons, between 2014-2015.

In the meantime, the analysis of national-level, integrated agricultural survey data has offered useful policy guidance. It suggests that smallholder agricultural commercialization can benefit household diet quality through the income pathway, and programs and policies that focus on increasing production of nutrient-rich foods can lead to increased consumption of these foods, regardless of income. Furthermore, agriculture programs that empower women and enable them to have greater control over assets and other decision-making will likely see improved dietary diversity independent of commercialization efforts.

Introduction and Background

Development policy is once again trending in favor of support to smallholder farmers as a key driver of poverty reduction in developing countries. In parallel to this renewed focus of agricultural policy, the international nutrition community has sought to take advantage of 'indirect', 'nutrition sensitive' approaches to improved nutrition, through pathways that stimulate the income and production capabilities of smallholders. Among the many interventions being rediscovered by nutrition practitioners, two in particular -- attention to improving production diversity, and smallholder commercialization -- are viewed as potentially promising mechanisms for stimulating the quantity and quality of dietary intake by smallholder households and for improving nutritional status.

Yet, there remains controversy over whether, and under what circumstances, such interventions are likely to be effective. While many studies of commercialization and nutrition have found that increased market engagement by smallholders boosts income, food expenditures, and dietary intakes (see Kennedy et al 1992; von Braun and Kennedy 1986; von Braun and Kennedy 1994), others have documented negative effects on the health and nutrition of rural households, largely due to the tendency of cash cropping to shift control of income from women to men, who were more likely to spend this "lumpy" income on nonfood items (see Dewalt 1993; Kiriti and Tisdell 2003). Yet, while studies on the whole appear to have found improvements in dietary *energy* intakes from increased market engagement, the effects on diet quality and nutrient adequacy have not been widely studied (Arimond et al. 2011) and evidence of the effects commercialization on nutritional status generally suggest no significant relationship (Arimond et al. 2011; Masset et al. 2012).

Evidence of the relationships between increased production of nutritious food crops, the diversity of crop production, and linkages to improved overall dietary quality is similarly inconclusive. A recent systematic review by Masset et al. (2012) found that nutrition-based agricultural interventions were successful in promoting consumption of specific foods rich in protein and micronutrients, though the effects on overall diet were unclear. Their findings largely echoed those of predecessor reviews (Leroy and Frongillo 2007, Ruel 2001, Berti et al. 2003, World Bank 2007) which observed that most individual studies typically assessed only the consumption impacts of the target crop but not the impact on overall diet, thus ignoring potential substitution effects. Similarly, most studies measured changes in production of the specific type of crop or crop category promoted by the program, rather than the overall cropping pattern. Moreover, very few of these studies isolated the pathway (e.g. income vs. direct consumption) through which these production diversification interventions achieved their effects. As Haddad (2013) highlights, though evidence suggests that increasing the production of nutritious foods will also increase their consumption, the extent to which this is true in various contexts and circumstances is largely unknown. And, while the literature on agriculture production and sales-related predictors of dietary diversity is thin, there are also gaps in knowledge of the predictors of improved dietary diversity more generally, as researchers have traditionally studied the demand for caloric sufficiency more than dietary quality (Rashid et al 2011).

The current study seeks to bolster this evidence base by addressing the following three questions:

1) Is agricultural commercialization associated with greater household dietary diversity and, if yes, under what circumstances?

2) Is greater food production diversity associated with dietary diversity? To what extent does the production of a specific food group increase the likelihood of its consumption?

3) What other factors are associated with dietary diversity among smallholder rural Ethiopian households, and how do these factors interact with commercialization to affect dietary diversity outcomes?

The study uses a unique, recently released national level data set from Ethiopia: the "2012 Living Standards Measurement Study-Integrated Survey on Agriculture, Ethiopia Rural Socioeconomic Survey" (LSMS-ISA: ERSS), implemented by the Ethiopian Central Statistics Agency (CSA) with technical support from the World Bank. The purpose of the LSMS-ISA: ERSS was to integrate data collected in the Ethiopian annual Agriculture Sample Survey with socio-economic, nutrition, and other multi-sectoral data typically collected through LSMS-style surveys. The results of this analysis are relevant to ongoing policy and programmatic initiatives in Ethiopia, including the Agriculture Growth Promotion program, which features smallholder commercialization as its centerpiece, and the ENGINE Program, which seeks to integrate 'nutrition-sensitive' activities into a broader portfolio of nutrition-specific interventions.

Methods

Study population and design

The data used for this research are derived from the 2012 Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA): Ethiopia Rural Socioeconomic Survey (ERSS), implemented by the World Bank and Ethiopian Central Statistics Agency (CSA). The 2012 survey was the first round of a long-term project intended to collect panel data on the characteristics, welfare, and agricultural activities of rural and small town households. The full sample was comprised of 290 rural and 43 small town CSA enumeration areas, covering all 9 regions of the country.[1] The capital city administration area of Addis Ababa was excluded from the sample. A total of 3,996 households were interviewed for the ERSS, using a two-stage probability sample (Ethiopian Central Statistics Agency and World Bank 2012)

The present analysis included only smallholder agricultural households involved in crop production (with or without livestock). Though the definition of "smallholder" is highly debatable, the World Bank's definition of "cultivating less than two hectares of land" was used (World Bank 2003). Based on this criterion, a total of 2,234 households were included in the sub-sample analyzed in this paper. The variables included in the analysis were derived from the household and post-harvest agriculture

[1] The sample was not representative of each of the small regions: Afar, Somalie, Benshagul Gumuz, Gambelia, Harari, and Diredwa. In analysis, small regions were aggregated into an "other region" category as suggested in the LSMS manual. No households in the Addis Ababa region fit the study inclusion criteria.

questionnaires (both administered between January and March 2012) and the livestock questionnaire (administered between November and December 2011).

Measurements and Limitations

The dependent variable of primary interest, household dietary diversity, was constructed using data from the household questionnaire's food frequency module, in which respondents were asked to recall which food groups they or anyone in their household had consumed in the previous 7 days. This information was used to calculate a household dietary diversity score (HDDS) by summing the number of food groups that had been consumed by anyone in the household. Though the standardized Food and Nutrition Technical Assistance (FANTA) Project HDDS score uses a 24-hour recall, the ERSS questionnaire inquired only about the previous week. Coates et al found that a 7-day dietary diversity score was more highly correlated with nutrient adequacy than a one-day dietary diversity score (Coates et al. 2007). The 12 food groups used to construct the HDDS correspond to those defined by FANTA (Swindale and Bilinsky 2006): (i) cereals; (ii) roots and tubers; (iii) pulses, legumes, and nuts; (iv) vegetables; (v) fruit; (vi) meat, poultry, and offal; (vii) fish and seafood; (viii) eggs; (ix) dairy products; (x) oils and fats; (xi) sugar and honey; and (xii) condiments. Each group was counted only once, resulting in a possible range of scores from zero to 12. A second "frequency-weighted" score was also calculated, summing the number of days each food group was consumed. However, results did not differ considerably and so the original 0-12 score was used in analysis. For descriptive analyses, households were grouped into clusters of similar scores using k-means cluster analysis, which identified three distinct groups: those with scores ranging from 1 to 4 (labeled "Below Average"), 5 to 6 (labeled "Average," as the overall mean was 5.4), and 7 to 12 ("Above Average"). These scores reflect dietary diversity during the time of survey implementation, which occurred during the post-harvest period (from January to March). In this particular season, food is relatively plentiful in most regions of the country.

Our intention was to operationalize the primary independent variable of interest, "degree of agricultural commercialization", using the most commonly cited definition, "proportion of total harvest sold," (Govereh et al 1999; Agwu and Mendie 2012), as this indicator captures the trade-offs made by households, at any level of market engagement, between production and consumption. Though this variable should have been available through the ERSS data set, an error in their training manual meant that enumerators did not collect self-reported harvest/yield information for most crops, making it impossible to calculate total yields. As an alternative, we defined this key variable per Gebreselassie and Sharp (2007) and Makhura et al (1998), as total earnings from the sale of crops, livestock, and agricultural byproducts in the previous 12 months. These authors cite this indicator as a preferred metric to proportion-based commercialization indicators, as it differentiates the scale of market participation, even among households that may sell the same proportion of their total output. Households with low agricultural income are considered "less commercialized" than those with higher agricultural income by this definition. To facilitate comparisons between commercialization levels, this agricultural income variable was also converted into quartiles.

A second key independent variable, production diversity, was defined both by the total number of different crops harvested in the previous 12 months, and by the total number of different crop *categories* harvested. Crop categories included cash crops, cereals, roots/tubers, pulses, vegetables, fruits, oil seeds, and spices.

Statistical analysis

To represent the national-level population of rural and small town households, population weights were used and all analysis was done using Stata's "svy" commands. Weighted means and standard deviations were calculated for continuous variables, and statistical comparisons of means between agricultural income groups and HDDS clusters were made using Adjusted Wald F tests (as ANOVA tests are not possible with survey commands). For highly skewed variables, the median and IQR (inter-quartile range) were calculated and significance tests were carried out using variables transformed to meet the assumption of normal distributions. To assess associations between categorical variables, a chi-square analysis (using the Rao Scott correction for complex survey designs) was used. Ordinary Least Squares (OLS) and Poisson regression analyses were then conducted to test the association between agricultural commercialization and dietary diversity and to identify other predictors of dietary diversity while controlling for possible confounders. While the Poisson approach is more appropriate for predicting count data (in this case, the HDDS), results did not differ considerably between the two models and so only the OLS results predicting HDDS are presented, as they are more easily interpreted. Logistic regression analysis was also used to predict household consumption of specific food groups. Statistical significance was set at $p < 0.05$ and all analyses were performed using Stata version 12 (StataCorp 2011).

Results: Descriptive Statistics

Table 1 presents summary statistics for demographic characteristics of smallholder households, disaggregated by agricultural commercialization level. Households in the higher commercialization quartiles were larger, predominantly male-headed, and younger than those in lower quartiles. For instance, only 10.9% of households in the highest quartile were headed by females compared to 30.1% in the lowest quartile. Twenty-seven percent of females in the highest agricultural commercialization level had some form of formal education, compared to only 18.1% in the lowest.[2] This positive association between education and commercialization was also evident among heads of household, with 43.4% in the highest agricultural income quartile reporting being educated compared to 29% in the lowest. Roughly half of all households reported that a female owned at least one large asset, a proxy for female empowerment (Alkire et al. 2013). This indicator, too, increased slightly with commercialization level. The median number of hours worked by the adult female (defined specifically as hours spent collecting water and fuel, time in agricultural activities, non-agricultural enterprise, and all paid and un-paid labor) was 3.5 hours per day, a level that did not vary significantly by agricultural commercialization level. This average is surprisingly low, though hours spent in domestic activities were not included in this questionnaire, which may explain this unexpected result. The number of shocks a household experienced in the past year also did not vary with commercialization level, at an overall mean of 1.1.

[2] Index female operationalized as the eldest adult female between the ages of 18 to 65, or the eldest female adult (18+) if there was only one female in the household.

Table 1. Summary table of demographic characteristics, by agricultural commercialization level

Characteristic	Overall	Agricultural Income Quartile: Lowest	2nd	3rd	Highest
	n=2,234	n=645	n=511	n=536	n=542
	Mean(SD)/ Median[IQR]/%	Mean(SD)/ Median[IQR]/%			
Adult equivalents (AE)[1]	2.4 [1.2]	2.1 [0.9]	2.4 [1.2]	2.4 [1.0]	2.7 [1.2]
Age of head of household	44.3 (14.7)	45.9 (16.7)	44 (14.4)	44.3 (14.5)	43.1 (13.0)
Age of adult female	37.4 (13.2)	39 (15.7)	37.5 (13.3)	36.8 (12.4)	36.2 (10.9)
Female head of HH (%)	20.0%	30.1%	21.2%	17.6%	10.9%
Female educated[2] (%)	20.3%	18.1%	16.8%	19.0%	27.3%
HH head educated (%)	35.2%	29.0%	29.5%	39.0%	43.4%
Female labor time (hrs/day)	3.5 [5.3]	3.5 [5.2]	3.2 [5.0]	3.4 [5.0]	3.5 [5.3]
Female owns ≥1 large asset[3]	50.3%	46.2%	47.4%	52.2%	55.3%
No. of shocks in past year	1.1 (1.2)	1 (1.2)	1.1 (1.1)	1.1 (1.2)	1.2 (1.1)
Region (%):					
Tigray	8.2%	12.7%	9.5%	5.6%	4.9%
Amhara	26.1%	28.8%	25.7%	24.5%	25.4%
Oromia	27.1%	24.6%	22.3%	26.3%	35.2%
SNNP	34.2%	26.9%	39.6%	39.4%	31.1%
Other region[4]	4.4%	7.0%	2.8%	4.3%	3.4%

Note: Estimates are weighted; Percentages shown are column percentages

[1] Calculated using OECD modified equivalence scale, assigning a value of 1 to the household head, 0.5 to each additional adult member, and of 0.3 to each child.

[2] "Educated" defined by ≥1 year of formal education

[3] Female owns/shares ownership of at least one asset, excluding small consumer durables and non-mechanized farm equipment

[4] "Other region" includes Afar, Somalie, Benshagul Gumuz, Gambelia, Harari, and Diredwa

Table 2 presents results pertaining to income, wealth, and expenditures of smallholder households, disaggregated by level of dietary diversity. Not surprisingly, HDDS cluster was significantly and positively associated with agricultural income, non-agricultural income, and total annual income (all at $p < 0.001$). The majority of income in this population derived from agricultural sales, as the median percent of total income from agriculture was 75.2%. The closer a household was to a major market (defined in the ERSS data as the "distance to the nearest FEWSNET key market center"), the higher their household dietary diversity level ($p < 0.1$). Across all households, the median distance to a major market was 54.8 kilometers.

As expected, dietary diversity also increased significantly with wealth ($p < 0.001$). Wealth was measured by constructing an index, similar to those used by the Demographic Health Survey (Rutstein and Johnson 2004). Using ordinal data on asset ownership and household characteristics, scores were produced from polychoric principal component analysis (a method proposed by Kolenikov and Angeles (2009) to be most appropriate for discrete data) allowing households to be grouped into quintiles. **Table 2** shows a strong association between wealth and HDDS, with chi-squared tests showing differences in proportions between the three groups significant at 5% or less. Results regarding share of total expenditure on food also showed a positive association with household dietary diversity. The mean percentage of expenditures on food was 35.7% in the “Below Average” HDDS cluster and 49% in the “Above Average” cluster ($p < 0.001$). This was surprising given that higher proportions of total expenditure spent on food typically represent a more food insecure situation, so the relationship is the inverse of what would be expected. Another variable chat consumption, was hypothesized to negatively affect dietary diversity through possible appetite suppressing and substitution effects. Chat consumption was reported by only 14.1% of smallholders overall,[3] but nearly a quarter of households in the highest HDDS cluster reported chat consumption in the previous 7 days compared to only 6.3% in the “Below Average” cluster ($p < 0.001$). Nonetheless, weekly expenditure on chat did not differ significantly across groups, as households in higher HDDS clusters were consuming largely from their own production rather than diverting household expenditures from food to chat.

[3] Chat consumption data was collected at the household level, therefore, it is unknown which members of the household were consuming the chat.

Table 2. Comparison of income, wealth, and expenditures, by household dietary diversity score cluster

	Overall n=2,215	Household Dietary Diversity Score Cluster: Below Average (1-4) n=687	Average (5-6) n=903	Above Average (7-12) n=625	
	Mean(SD)/ Median[IQR]/%	Mean(SD)/Median[IQR]/%			Sig.
Agricultural income (Birr)[1]	1,100 [2,785]	588 [1,853]	1,303 [2924]	1,792 [3,828]	***
Non-agricultural income (Birr)[2]	225 [1,925]	225 [1,200]	116 [1,620]	720 [5,000]	***
Total annual income (Birr)[3]	2,460 [4,854]	1,303 [2,850]	2,646 [4,475]	4,210 [9,473]	***
Percent total income from agriculture	75.2 [80.2]	61.0 [85.8]	90.0 [71.1]	70.0 [83.2]	**
Distance to nearest major market (km)	54.8 [57.8]	58.1 [57.7]	50.5 [54.7]	53.1 [56.5]	+
Wealth index quintile (%):					
Poorest quintile		35.0%	16.4%	7.8%	***
2nd quintile		24.5%	20.3%	14.8%	**
3rd quintile		21.5%	22.5%	14.9%	*
4th quintile		10.9%	23.9%	24.4%	***
Wealthiest quintile		8.1%	16.9%	38.1%	**
Total weekly expenditure per AE (Birr)	40 [48]	25 [25]	43 [45]	63 [66]	***
Mean food expenditure share (%)	42.8 (24.7)	35.7 (26.1)	43.9 (24.1)	49.0 (22.4)	***
Consumed chat in past 7 days (%)	14.1%	6.3%	13.6%	23.7%	**
Chat expenditure (Birr/wk)[4]	23 (43)	27 (61)	28 (46)	17 (34)	NS
Share of chat consumed from own production (%)	52.3 (45.1)	40.4 (49.1)	41.8 (47.2)	64.9 (39.1)	**

Significance based on Rao Scott chi-squared test for differences in proportions or Adjusted Wald F test on means of continuous variables (transformed if non-normally distributed); + p<0.1, * p<0.05, ** p<0.01, *** p<0.001

¹ Includes: crop sales, crop byproduct sales, livestock sales, and livestock byproduct sales from the previous 12 month

² Income from wages, gratuities, in-kind payments, pensions, investments, rental income, sales of assets, plus the value of cash, food, and other in-kind gifts and assistance.

³ The average total income is higher than the averages of agricultural and non-agricultural combined because the table presents *medians* and not *means.*

⁴ Among only chat consuming households (n=427)

Table 3 presents household dietary diversity results, both across the total sample of smallholders and disaggregated by agricultural income quartile. The mean HDDS was 5.4 out of 12 and increased significantly with agricultural commercialization level ($p < 0.001$). Another commonly used dietary diversity measure, the World Food Program's Food Consumption Score (FCS) (WFP 2008) showed a similar positive association with agricultural income ($p < 0.001$)[4] . The most frequently reported food groups consumed were cereals, oils/fats, condiments, and pulses, all consumed by 66% or more of households. While there was no significant difference in cereal or condiment consumption across agricultural income quartiles (both consumed by nearly all households), the proportion consuming

[4] The FCS is a weighted, composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups.

oils/fats and pulses increased with higher agricultural income levels. The differences in oil/fat consumption were highly significant at $p < 0.001$, while the differences in pulse consumption were only statistically significant at $p < 0.1$. Other notable differences were found in the consumption of vegetables and dairy products, which were consumed by 48.6% and 38.3% of overall households respectively, and increased significantly with agricultural income (both significant at $p < 0.001$). Meat, fruit, egg, and seafood consumption were relatively low overall and were not found to be associated with agricultural commercialization level.

Table 3. Comparison of household dietary diversity, by agricultural commercialization level

		Agricultural Income Quartile				
	Overall n=2,215[1]	**Lowest** n=634	**2nd** n=507	**3rd** n=533	**Highest** n=541	
Characteristic	Mean(SD)/%	Mean(SD)/%				**Sig.**
Household Dietary Diversity Score (0-12)	5.4 (1.7)	4.9 (1.8)	5.2 (1.5)	5.6 (1.6)	6 (1.5)	***
Food Consumption Score (FCS) (0-112)	40 (16.2)	35.1 (15.5)	36.9 (14.6)	40.6 (15.6)	47.4 (16.5)	***
Household consumed any in past 7 days (%):						
Cereals	95.3%	93.7%	94.5%	95.4%	97.5%	NS
Roots and tubers	44.0%	38.0%	48.9%	45.6%	43.6%	NS
Pulses/legumes/nuts	66.4%	63.8%	62.4%	66.3%	73.0%	+
Vegetables	48.6%	34.9%	49.0%	48.3%	62.1%	***
Fruits	14.9%	15.4%	11.2%	16.0%	16.9%	NS
Dairy products	38.3%	24.4%	32.1%	43.3%	53.3%	***
Meat, poultry, offal	26.2%	23.4%	26.1%	27.6%	27.7%	NS
Fish and seafood	0.9%	0.9%	1.0%	0.2%	1.6%	NS
Eggs	11.3%	12.5%	9.8%	10.1%	12.9%	NS
Oil/fats	72.9%	64.7%	67.7%	76.6%	82.4%	***
Sugar/honey	32.1%	28.8%	27.8%	33.3%	38.3%	+
Condiments	93.2%	91.5%	91.3%	95.5%	94.5%	NS

Significance based on Rao Scott chi-squared test for differences in proportions or Adjusted Wald F test on means of continuous variables; + p<0.1, * p<0.05, ** p<0.01, *** p<0.001

[1] 19 households missing dietary diversity data

Table 4 presents a comparison of agricultural commodities produced by smallholders, disaggregated by the three household dietary diversity score clusters. Analyses showed significant differences among these dietary diversity score clusters with regard to both the number and types of crops grown. Households in the “Above Average” HDDS group produced more specific crop varieties than those in the other groups ($p < 0.05$) produced more types of crops (categorized into groups, such as vegetables, fruits, tubers, non-food cash crops etc.) ($p < 0.05$), and grew more types of cash crops ($p < 0.001$). However, as discussed in the presentation of regression results to follow, this result for crop diversity loses significance after controlling for other predictors of dietary diversity. Cash crops include chat, coffee, cotton, enset,[5] hops (“gesho”), sugar cane, tea, tobacco, and sisal. Sixty-eight percent of households in the “Above Average” HDDS group produced cash crops compared to 59.3% in the “Average” group and 45.4% in the “Below Average” group ($p < 0.001$). There was also a highly significant and positive association between fruit production and HDDS group, with 35.2% of the “Above Average” households producing fruit, compared to just 17% in the “Below Average” group ($p < 0.001$). Aside from a slightly significant ($p < 0.1$) positive association between vegetable production and HDDS group, no other statistically significant relationships were found between HDDS cluster and the type of crop category produced. Given that there was no notable association between field area and HDDS, it is possible that the number of different types of crops produced may impact dietary diversity more than the *amount* produced.

Livestock was also a major component of smallholder agricultural activity. As shown in **Table 4**, the majority of households reported at least some livestock ownership (86.3%). While the indicator, “owning any livestock” was not significantly associated with HDDS cluster (possibly due to low variability in the indicator), a significantly positive association was found between Total Livestock Units (TLUs) owned and HDDS cluster. TLUs were calculated using FAO conversion factors to standardize livestock units (FAO 2011). The median number of TLUs increased with HDDS cluster from 1.3 to 1.5 to 1.6 ($p < 0.001$). In addition to livestock ownership, many households (66.3%) also reported production of various livestock byproducts, including dairy, eggs, honey, meat, and non-food products such as hides and wool. The only byproduct found to be significantly associated with HDDS cluster was dairy, which was more often produced by those in the “Above Average” HDDS group.

[5] Though enset is also a food crop this categorization as a cash crop is aligned with the definition adopted by the LSMS.

Table 4. Comparison of agricultural commodities produced, by household dietary diversity score cluster

Characteristic	Overall n=2,234 Mean(SD)/ Median[IQR]/%	Household Dietary Diversity Score Cluster: Below Average (1-4) n=687	Average (5-6) n=903	Above Average (7-12) n=625	Sig.
		Mean(SD)/Median[IQR]/%			
Field area (hectares)	0.8 (0.5)	0.8 (0.5)	0.8 (0.5)	0.9 (0.5)	NS
Produced any of following crops:					
Cash crops[1]	57.2%	45.4%	59.3%	67.5%	***
Cereals	87.9%	90.3%	88.9%	83.8%	+
Pulses	50.0%	50.1%	50.8%	49.1%	NS
Vegetables	46.0%	39.7%	48.8%	48.2%	+
Root and tubers	40.2%	35.5%	40.4%	45.0%	NS
Fruits	25.9%	17.0%	26.9%	35.2%	***
Oil seeds	24.8%	29.3%	23.0%	22.4%	NS
Spices	13.2%	12.8%	14.1%	12.9%	NS
No. crops produced	5 [4]	5 [4]	5 [5]	6 [4]	*
No. food crops	4 [3]	4 [3]	4 [4]	5 [3]	NS
No. cash crops	1[2]	0 [1]	1 [2]	1 [2]	***
No. crop categories[2] produced (1-8)	3 [3]	3 [2]	3 [3]	4 [3]	*
Any livestock owned	86.4%	84.3%	87.1%	87.8%	NS
Total livestock units (TLU)[3] owned	1.5 [2]	1.3 [1.8]	1.5 [2.1]	1.6 [2.3]	***
Any of following livestock byproducts produced:	66.3%	62.4%	68.5%	68.4%	NS
Dairy products	43.1%	35.0%	44.9%	49.7%	**
Eggs	43.1%	42.5%	45.0%	48.0%	NS
Honey	4.9%	5.0%	4.1%	6.3%	NS
Meat	12.0%	13.3%	11.4%	11.7%	NS
Non-food livestock byproducts	40.8%	39.6%	41.1%	42.4%	NS

Significance based on Rao Scott chi-squared test for differences in proportions or Adjusted Wald F test on means of continuous variables (transformed if non-normally distributed); + p<0.1, * p<0.05, ** p<0.01, *** p<0.001

[1] Cash crops include chat, coffee, cotton, enset, hops ("gesho"), sugar cane, tea, tobacco, and sisal

[2] Crop categories include: cash crops, cereals, roots/tubers, pulses, vegetables, fruits, oil seeds, and spices

[3] Total number of livestock owned by the household at the time of survey, standardized using FAO conversion factors

Table 5 presents descriptive analyses of household sources of agricultural income, overall and across the three HDDS clusters. While the majority of households reported earning at least some agricultural income (88.6%), the proportion reporting agricultural income increased with HDDS group from 84.4% to 90.2% to 91.1% ($p < 0.01$). This positive association between HDDS group and agricultural income quartile was also noted in **Table 3.** The majority of smallholders sold at least one crop (71.9%), with an average of 2 crops per household across 1.6 different crop categories. Less than 5% processed and sold crop byproducts (such as flour, beer, etc.) whereas 40% of smallholders sold livestock and/or livestock byproducts. The mean income from the sale of live animals was 846 Birr in the “Below Average” HHDS group, 1,064 Birr in the “Average” group, and 1,328 Birr in the “Above average” group ($p< 0.001$). Likewise, cash crop income and share of total agricultural income from cash crops were significantly positively associated with HDDS. The “Below Average” HDDS group earned a mean of only 263 Birr from cash crop sales, compared to 490 Birr and 1,161 Birr in the “Average” and “Above Average” groups, respectively ($p < 0.001$). Notably, mean food crop income was not significantly associated with HDDS cluster, and the share of total agricultural income from food crops was inversely correlated with dietary diversity ($p < 0.05$).

Table 5. Comparison of sources of agricultural income, by household dietary diversity score cluster

		Household Dietary Diversity Score Cluster			
	Overall n=2,215	Below Average (1-4) n=687	Average (5-6) n=903	Above Average (7-12) n=625	
Characteristic	Mean(SD)/ Median[IQR]/%	Mean(SD)/Median[IQR]/%			Sig.
Any agricultural income (%)	88.6%	84.4%	90.2%	91.0%	**
Any crops sold (%)	71.9%	66.3%	72.8%	77.2%	*
No. of crops sold	2 (1.2)	1.8 (1)	2 (1.1)	2.1 (1.3)	*
No. of crop categories sold[1]	1.6 (0.8)	1.5 (0.7)	1.7 (0.9)	1.6 (0.8)	*
Any crop byproducts sold (%)	4.2%	3.5%	4.6%	4.5%	NS
Any livestock sold (%)	43.3%	36.6%	44.6%	48.9%	**
Any livestock byproducts sold (%)	44.4%	41.3%	48.1%	42.3%	NS
Mean income from (Birr)[2]:					
Cash crops	606 (1,817)	263 (966)	490 (1,352)	1161 (2,804)	***
Food crops	606 (1,797)	467 (1,508)	677 (2,023)	657 (1,744)	NS
Crop byproducts	206 (1,920)	137 (1,439)	204 (2,080)	290 (2,151)	NS
Livestock	1,067 (2,044)	846 (1,807)	1064 (1,926)	1328 (2,428)	*
Livestock byproducts	238 (695)	146 (400)	272 (787)	292 (798)	**
Mean share of agricultural sales (%)[2]:					
Cash crops	22.2% (35.8)	16.9% (33.7)	21.8% (35)	28.6% (38.2)	*
Food crops	30.4% (38.4)	36.1% (40.9)	28.3% (36.9)	26.5% (36.4)	*
Cereals	12.2% (26.9)	15.1% (30.3)	9.9% (23.4)	12.1% (27.2)	+
Roots and tubers	2.9% (13)	3.8% (15.8)	2.7% (11.9)	1.9% (9.8)	+
Pulses	3.9% (15.1)	4.8% (16.6)	4.2% (15.2)	2.6% (13.2)	*
Vegetables	2.7% (13.2)	2.8% (13.4)	2.6% (12)	2.3% (13.9)	NS
Fruits	2.8% (12.5)	2.4% (12.1)	2.7% (12.5)	3.5% (13.1)	NS
Oil seeds	5.4% (19.3)	6.4% (20.9)	5.8% (19.8)	3.8% (16)	NS
Spices	0.4% (5.2)	0.7% (7)	0.4% (4.7)	0.3% (2.8)	NS
Crop byproducts	2.9% (14.6)	2.6% (13.4)	3.1% (15.2)	3.0% (15)	NS
Live animals	29.8% (37.8)	27.9% (37.8)	30.8% (37.8)	30.5% (37.7)	NS
Livestock food byproducts	13.1% (25.5)	13.9% (26.9)	15% (26.7)	9.7% (21.5)	**
Dairy products	7.6% (20.1)	7% (20.6)	9.3% (21.6)	6% (16.8)	*
Eggs	4.5% (15)	5.4% (16.8)	4.9% (15.4)	3% (11.9)	+
Honey	0.8% (6.6)	1.2% (7.4)	0.7% (6.4)	0.6% (5.8)	NS
Meat	0.1% (2.2)	0.3% (2.9)	0.1% (2.2)	0% (0.1)	+
Non-food livestock byproducts	1.7% (9.9)	2.6% (12.3)	1% (7)	1.7% (10.6)	**

Significance based on Rao Scott chi-squared test for differences in proportions or Adjusted Wald F test on means of continuous variables (transformed if non-normally distributed); + p<0.1, * p<0.05, ** p<0.01, *** p<0.001

[1] Crop categories include: cereals, roots/tubers, pulses, vegetables, fruits, oil seeds, and spices

[2] Denominators include only households with any agricultural sales in the previous 12 months (n=1,885)

Results: Regression Analyses

Table 6 presents results of the OLS regression predicting household dietary diversity score. All else equal, agricultural income was found to positively affect HDDS, with each 1,000 Birr of agricultural income associated with a 0.04 increase in HDDS ($p < 0.01$). This association was independent of the obvious confounders of non-agricultural income and wealth. Non-agricultural income was also significantly associated with HDDS ($p < 0.001$). Furthermore, an F test on the coefficients of agricultural income and non-agricultural income, yielded a p value of less than 0.05, suggesting the effect of the two variables on HDDS is not equal. Wealth was found to be independently one of the strongest predictors of HDDS, as each wealth index quintile was associated with significantly higher HDDS compared to the poorest quintile. According to the model, holding other variables constant, a household in the wealthiest quintile reported consumption of an average of 1.2 more food groups than households in the poorest quintile ($p < 0.001$).

Agricultural income was also interacted with several variables to assess differential effects of commercialization on dietary diversity. The coefficient on the interaction of female household headship with total agricultural income was significantly positive with a coefficient of 0.05, meaning agricultural commercialization had a larger effect on household dietary diversity for female-headed households than male-headed households ($p < 0.05$). An interaction variable for educated females (a binary variable) and agricultural income was also included in the model and produced an inexplicably negative coefficient, slightly significant at $p < 0.1$. Overall, households with an educated adult female had an HDDS on average 0.4 higher than households with an uneducated adult female ($p < 0.05$), independent of whether or not the household head was educated. However, each 1,000 Birr of agricultural income was associated with a slightly *lower* HDDS in female educated households compared to households in which the female had no formal education ($p < 0.1$). Neither age of the adult female nor number of hours worked (“female labor time”) was associated with HDDS, while female ownership of at least one large asset, a proxy measurement of female empowerment, was associated with a 0.5 increase in HDDS ($p < 0.001$).

To address the second study question, the model also included several agricultural production variables hypothesized to correlate with HDDS. Field area, measured in hectares, was found to be associated with an increase of 0.3 in HDDS ($p < 0.05$). The number of food crops produced, a measure of production diversity, was expected to increase with dietary diversity, as a wider variety of foods were potentially readily available to the household to consume. However, no relationship was found between number of food crops produced and HDDS. Instead, a significantly positive relationship was found between number of cash crops produced and HDDS, as each additional cash crop produced was associated with 0.2 more food groups consumed ($p < 0.01$). Livestock ownership, as measured by number of TLUs, was not significantly associated with HDDS. Controlling for total agricultural income, it was hypothesized that the *share* of agricultural income from food crops, cash crops, and livestock may be correlated with HDDS, though only livestock agricultural income share was found to have a significant positive association ($p < 0.05$).

Other predictors in the analysis included region, expenditures, household size (expressed in adult equivalents), distance to the nearest major market, and shocks. Certain regional effects were found to be statistically significant. Compared to households in the Tigray region, the dietary diversity scores in households in Amhara were 0.7 lower ($p < 0.001$). However, distance to the nearest major market was not found to be an independent predictor of HDDS. Weekly chat expenditure was found to be slightly positively associated with HDDS ($P < 0.1$), as was the share of total expenditures spent on food ($p < 0.001$). The number of adult equivalents living in the household and the number of shocks experienced in the past year were both included in the model as they are known to often cause strain on household food supplies. However, neither variable was significantly associated with HDDS.

To identify predictors of the consumption of specific food groups, logistic regression analyses were conducted (**Table 7)**. Cereal and condiment consumption were not included in the models, as nearly all households consumed these food groups. While the OLS model, discussed previously, identified a positive relationship between agricultural income and household dietary diversity, the logistic models showed that agricultural income (included in the model as quartiles) was significantly *positively* associated with only consumption of vegetables and dairy. Households in the highest quartile of agricultural income were twice as likely to have consumed vegetables and twice as likely to have consumed dairy as households in the lowest quartile, all else equal ($p < 0.05$ for both). However, the inverse effect was found with root consumption, which was less likely to be consumed by the highest quartile households, compared to the lowest quartile (OR=0.6, $p < 0.05$). Independently, non-agricultural income was found to have a statistically significant, yet very small effect on meat and egg consumption (both at $p < 0.01$). Not surprisingly, wealth was found to be a significant predictor in six of the models, with the wealthiest households significantly more likely to eat vegetables, fruit, oils/fats, sugar/honey, meat, and eggs compared to the poorest households, controlling for all other variables (all significant at $p < 0.05$ or less).

To answer the question of how production and sale of specific crop types might impact household diet, a categorical variable was included in the logistic regression models that was coded as 0 if the food group was not produced by the household, 1 if it was produced but not sold, and 2 if it was produced and any amount was sold. Using "produced but not sold" as the base, the models showed that production of most food groups was positively associated with consumption of the food group. For example, households that did *not* grow vegetables were nearly 50% *less likely* to consume a vegetable in the past week ($p < 0.05$). The exceptions were the production and/or sale of roots, sugar/honey, and meat, which were not significantly associated with the consumption of these respective food groups. Furthermore, the association between production and consumption of the oils/fat food group had an inverse relationship, as households *not* producing oil seeds were *more* likely to consume oils/fat (OR=1.7, $p < 0.05$). The odds ratios for the category of "Produced and sold" compare the odds of consuming specific food groups to households producing but *not* selling said food group. Holding all other variables in the models constant, this variable was only statistically significant in the fruit consumption model, where households who produced *and* sold fruit were twice as likely to consume fruit as those who produced but did not sell fruit ($p < 0.05$). While this result may seem surprising, readers should note that the recall period for harvest data was 12 months, while the recall for consumption data was 7 days. It is therefore possible that seasonality effects of the different recall periods may have influenced this result.

Several other variables were found to be significant predictors of specific food group consumption, including those related to female characteristics. Notably, female-headed households were significantly more likely to have reported household vegetable consumption than male-headed households (OR=1.5, $p < 0.05$), but less likely to have reported sugar/honey (OR=0.7, $p < 0.05$) and meat consumption (OR=0.5, $p < 0.01$). Female asset ownership, a proxy for female empowerment, was associated with significantly higher probability of the consumption of roots, vegetables, oils/fats, sugar/honey, and meat (all significant at $p < 0.05$ or less). One of the most unexpected findings was that cash crop production (measured using a binary variable) significantly increased the likelihood of a household consuming roots, controlling for other variables (OR=2.9, $p < 0.001$). Further investigation would be needed to understand this particular result, as the researchers are not aware of what would explain the positive relationship between cash crop production and root consumption, given that root crops are generally inferior foods in the Ethiopian context. Lastly, the results showed clear regional differences in dietary patterns, as evidenced by high odds ratios in many of the models. For example, households in SNNPR were 10 times as likely to consume roots, 17 times as likely to consume vegetables, 4.5 times as likely to consume fruit, and 2.4 times as likely to consume dairy as households in Tigray (all significant $p < 0.01$ or less). Households in Tigray were significantly more likely to consume meat and eggs than households in each of the other regions ($p < 0.001$).

Table 6. OLS Regression Results Predicting Household Dietary Diversity Score (0-12)

Independent Variables	**HDDS**
Agricultural income (in thousands of Birr)	**0.037****
Non-agricultural income (in thousands of Birr)	**0.006*****
Wealth index quintile[1]:	
2nd quintile	0.283+
3rd quintile	0.396**
4th quintile	0.731***
Wealthiest quintile	1.213***
Female head of HH	-0.120
Female head of HH*Total ag income (in thousands of Birr)	**0.048***
Female educated	**0.354***
Female educated*Total ag income (in thousands of Birr)	-0.039+
HH head educated	0.223*
Female owns >=1 large asset	**0.535*****
Female age	-0.001
Female labor time (hrs/wk)	-0.022
Share of agricultural sales from (%):	
Food crops	0.001
Cash crops	-0.002
Livestock	**0.003***
No. food crops produced	-0.015
No. cash crops produced	0.194**
Total Livestock Units owned	0.042
Region[a]:	
Amhara	-0.729***
Oromia	0.330
SNNP	0.337
Other region	-0.113
Field area (hectares)	**0.248***
Adult equivalents	-0.018
No. shocks in past yr.	-0.021
Chat expenditure (Birr/wk)	0.003
Food expenditure share (%)	**0.016*****
Distance to major market (km)	-0.003
Constant	3.650***
Observations	2,005
F	25.397
R^2	0.355

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

[a] Reference categories: Poorest wealth quintile, Tigray region

Table 7. Logistic Regression Results Predicting Food Group Consumption

	Odds Ratios								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Independent Variables	**Pulses**	**Roots**	**Vegetables**	**Fruits**	**Oil/Fats**	**Sugar/Honey**	**Dairy**	**Meat**	**Eggs**
Agricultural income quartile[a]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2nd quartile	0.83	0.94	1.35	0.68	0.89	1.11	1.30	1.12	0.71
3rd quartile	1.01	0.60*	1.15	0.72	1.36	1.16	1.54+	1.20	0.77
Highest quartile	1.39	0.56*	2.16*	0.90	1.33	0.92	1.92*	0.96	0.74
Non-agricultural income (thousands of birr)	1.00	1.01+	1.01	1.00+	1.01	1.00	1.00	1.01**	1.00**
Wealth index quintile[a]:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2nd quintile	0.98	1.18	1.57	1.49	1.18	1.08	1.31	1.16	2.09+
3rd quintile	0.97	1.22	1.07	2.23*	1.54+	1.31	1.02	1.91+	2.47*
4th quintile	1.16	1.05	1.84+	2.69*	2.03*	1.94*	1.47	1.91+	4.36***
Wealthiest quintile	1.21	1.71	2.77**	4.29***	3.56***	3.66***	1.54	2.59*	4.13***
Produced cash crops	1.34	2.87***	1.43	1.02	0.76	0.96	1.48+	1.15	0.75
No. crop categories harvested	0.97	0.86+	0.78*	0.88	1.16+	0.93	0.83**	0.95	1.10
Total Livestock Units owned	0.94	1.03	0.91	0.82	1.05	1.05	1.19**	1.02	1.04
Sold livestock	0.87	1.61*	1.34	1.41	1.10	1.55*	1.22	1.18	1.13
Produced/Sold[b]:									
Not produced	**0.51*** **	0.79	**0.57** **	**0.38*** **	**1.73** **	0.92	**0.26*** **	0.93	**0.43*** **
Produced & Sold	1.20	1.17	0.88	**1.99** **	1.87+	0.80	0.76	0.53	0.79
Field area (hectares)	1.43*	0.81	1.05	0.92	1.64**	1.03	1.19	1.53*	1.31
Distance to major market (km)	1.00	1.00	0.99+	1.01***	0.99***	1.00	1.00	1.01*	1.00
Female head of HH	0.99	1.05	1.46*	1.13	1.03	0.69*	0.90	0.50**	1.18
Female educated	1.35	1.18	1.17	1.09	1.32	1.11	1.40+	1.11	0.97
HH head educated	0.95	1.38+	1.24	1.03	1.16	1.10	1.02	1.06	1.53
Adult equivalents (AE)	0.83+	1.21+	1.29*	1.08	0.99	0.87	0.95	0.84	0.79+
Female labor time (hrs/wk)	1.04	0.98	0.98	0.97	0.98	1.01	0.97	0.96+	0.97
Female owns≥ 1 large asset	1.10	1.85**	1.50*	1.37	1.76*	1.73**	1.15	2.19***	1.33
No. shocks in past year	0.93	0.92	1.03	0.95	0.86+	1.24*	1.20**	0.87	1.11
Chat expenditure (Birr/wk)	1.00	0.99	1.00	1.01+	1.01	1.01+	1.01	1.00	1.00
Food expenditure share (%)	1.01**	1.01***	1.00	1.00	1.01*	1.01***	1.00	1.04***	1.01***
Region[a]:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Amhara	1.54	1.45	1.58	0.66	0.20***	0.65	0.74	0.17***	0.08***
Oromia	2.55*	1.16	4.45***	3.13*	1.42	0.84	3.30***	0.13***	0.26***
SNNP	1.22	9.75***	17.11***	4.67**	0.47	0.14***	2.40**	0.14***	0.13***
Other region	0.98	1.26	1.14	2.79+	1.02	1.56	3.04**	0.20***	0.18***
Observations	2005	2005	2005	2005	2005	2005	2005	2005	2005
F	2.74	6.09	6.80	8.47	7.13	6.19	8.26	5.68	3.55

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

[a] Reference categories: Lowest agricultural income quartile, Poorest wealth quintile, Tigray region

[b] Reference category is "Produced but did not sell [food group]"

Discussion

Results of this study suggest that smallholder commercialization in Ethiopia may have a positive effect on household-level dietary quality. Greater income from agricultural sales, controlling for non-agricultural income and other confounding variables, was associated with higher household dietary diversity, with female-headed households experiencing greater positive effects from commercialization than male-headed households. Furthermore, greater agricultural income significantly increased the odds of both vegetable and dairy consumption. Other variables found to be strong predictors of household dietary diversity were: share of agricultural income from livestock sales, field area, distance to a major market, region, chat expenditures, education, wealth, and female ownership of a large asset (a proxy for empowerment).

With regard to the relationship between production diversity and dietary outcomes, regression analysis showed no effect of food crop production *diversity* on consumption *diversity* controlling for other confounders. That said, cash crop production (a binary variable) was found to be a significantly *positive* predictor of dietary diversity, contrary to prior research suggesting potential negative impacts on household diet and health. And, regardless of cash crop production and across all income levels, households that produced vegetables, fruit, pulses, dairy, and eggs had a higher chance of consuming these foods than those that did not produce the foods at all. Selling these crops was not found to significantly affect their consumption, with the exception of fruit, which was more likely to be consumed by fruit-selling households compared to those that produced but did not sell fruit.

Certain limitations of the data must be kept in mind in interpreting these results. First, these data are cross-sectional, leading to potential endogeneity. For instance, one can't tell for certain from this initial survey round whether farm households participating in commercial sales become wealthier and earn more income leading to higher dietary diversity, or whether wealth and higher total income were necessary pre-requisites for commercialization. Second, due to the lack of yield data we were unable to account for the quantity of crops produced (only the variety). Yield data would also enable a definition of commercialization as a proportion of total harvest sold. This indicator would serve as a useful complement to the 'total ag income' indicator used in this analysis and enable a closer examination of the trade-offs that households face in deciding how much of own production to consume versus sell and the effects of these trade-offs.

Many of these limitations will be ameliorated through the Ethiopia/ENGINE Project-funded Agriculture-Nutrition Panel Survey, a longitudinal survey of 1200 rural households that will be implemented four times, across two seasons, between 2014-2015. This survey will enable the study of a number of questions that were inadequately analyzable using currently available secondary data, (e.g. what factors predict the share of own production that is sold versus directly consumed from homestead gardens and smallholder farms? Which nutrition-friendly practices appear to yield the greatest benefits and why? To what extent do nutrition considerations enter into production-related decision-making, with and without exposure to nutrition education?), as well as program specific questions (eg. what are the factors associated with program exposure to, participation in, and uptake of ENGINE’s nutrition sensitive activities? Through which pathways -- nutrition sensitive v. nutrition specific; income vs. direct consumption -- did ENGINE’s interventions achieve its impacts?). Through this rich dataset, we anticipate being able to examine nutrient adequacy outcomes and nutrition outcomes in addition to dietary diversity and to use intra-household data on crop control, decision-making, and empowerment to examine the distributional effects of aforementioned agricultural technologies.

In the meantime, the analysis of national-level integrated agricultural survey data has offered useful policy guidance. It suggests that smallholder agricultural commercialization can benefit household diet quality through the income pathway and programs and policies that focus on increasing production of nutrient-rich foods can lead to increased consumption of these foods, regardless of income. Furthermore, agriculture programs that empower women and enable them to have greater control over assets and other decision-making will likely see improved dietary diversity independent of commercialization efforts.

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